U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION
MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL MANAGEMENT

WATER-RESOURCES INVESTIGATIONS REPORT 93-4151
Bratton, Lisa, M.A. Horn, and Medalie, Laura, 1996. Estimated withdrawals and use of freshwater in Massachusetts, 1990

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INTRODUCTION

In 1977, the Congress of the United States, recognizing the need for accurate, comprehensive, and comparable information on water use, directed the U.S. Geological Survey (USGS) to establish a National Water-Use Information Program to complement other USGS programs on the availability and quality of the Nation's water resources. The Water-Use Program is a cooperative project between USGS offices and various State agencies who are responsible for water-resources management. Currently (1996), a comprehensive water-use program is in place in Massachusetts and the other five States in New England. These six individual programs are closely coordinated to promote development of uniform water-use data bases.

This report is in prepared in cooperation with the Massachusetts Department of Environmental Management and the Massachusetts Department of Environmental Protection and is based on data for Massachusetts that were compiled for a national report (Solley and others, 1993). National compilations have been done every 5 years since 1950. This 1990 report is one of six reports, being prepared for the New England States.

The purpose of this report is to provide information on water use in Massachusetts to Federal and State agencies, water-resource professionals, and individuals interested in water-conservation issues. The report focuses on freshwater withdrawals and instream use for hydroelectric-power generation during 1990. Water withdrawals and use are reported in million gallons per day and are generally derived by dividing total annual withdrawals and use by 365 days. This procedure does not affect the values reported for water-use activities that are fairly constant throughout the year, such as domestic withdrawals; however, for water-use activities with significant seasonal variations, such as sand-and-gravel mining and irrigation, the average daily withdrawal rate is smaller than the actual daily withdrawal rate during the season of activity.

Massachusetts State agencies use different river-basin delineations, than those used in this report, which are equivalent to the hydrologic cataloging units designated by the USGS in cooperation with the U.S. Water Resources Council. A complete description of the USGS units can be found in Seaber and others (1987). In most cases, river-basin boundaries (either State or USGS definitions) do not coincide with State boundaries, and the data reported here are only for the part of each river basin within Massachusetts. A reconciliation of the State and USGS river-basin delineations is provided in the table below. The largest difference between the two delineations is that the Charles, Cape Cod, and Narragansett Basins, as delineated by the USGS, each encompass several smaller basins as defined by the State.

The Massachusetts Department of Environmental Protection collects site-specific data on withdrawals for public supply and for other users that withdraw more than 100,000 gallons per day. These data have been supplemented by estimates derived in one of two ways. For withdrawals for thermoelectric-power generation, agriculture, and mining, and for instream use such as hydroelectric-power generation, site-specific information (such as amount of power generated, irrigated acreage, or production data) has been multiplied by a coefficient (Hansen and Lapham, 1991). For domestic, commercial, industrial, and agricultural withdrawals, aggregated data (such as census data) have been multiplied by a coefficient (U.S. Department of Commerce, 1989a, 1989b, 1989c).

REFERENCES CITED

Hansen, B.P., and Lapham, W.W., 1990, Geohydrology and simulated groundwater flow in the Plymouth-Carver aquifer, southeastern Massachusetts: U.S. Geological Survey Water-Resources Investigations Report 90-4204, 69 p.

Seaber, P.R., Kapinos, F.P., and Knapp, G.L., 1987, Hydrologic unit maps: U.S. Geological Survey Water-Supply Paper 2294, 63 p.

Solley, W.B., Pierce, R.R., and Perlman, H.A., 1993, Estimated use of water in the United States in 1990: U.S. Geological Survey Circular 1081, 76 p.

U.S. Department of Commerce, 1989a, 1987 census of agriculture, volume 1: geographic area series, part 21--Massachusetts: State and county data, Washington D.C., Bureau of the Census, publication AC87-A-21, 198 p.

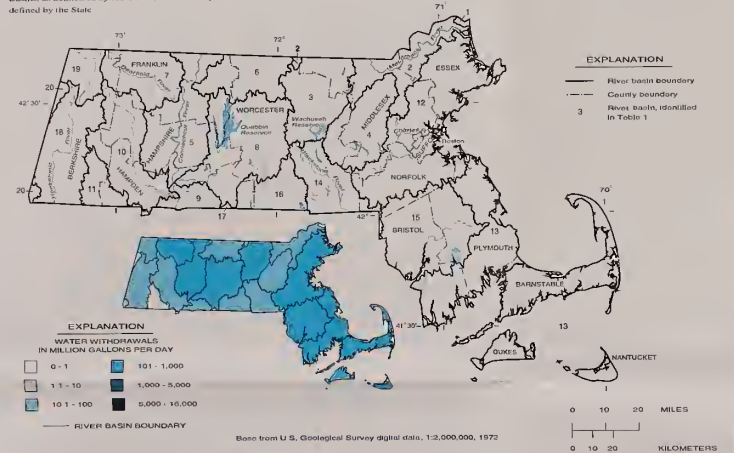
---- 1989b, 1987 census of retail trade, geographic area series, Massachusetts: Washington D.C., Bureau of the Census, publication RC87-A-22, 75 p.

--- 1989c, 1987 census of service industries, geographic area series, Massachusetts: Washington D.C., Bureau of the Census, publication SC87-A-23, 141 p.

---- 1991, 1990 census of population and housing, summary population and housing characteristics, Massachusetts: Washington D.C., Bureau of the Census, publication 1990/CPH-1-23, 174 p.

CONVERSION FACTORS

Multiply	by	To obtain
million gallons per day	0.04381	cubic meter per second
square miles	2.590	square kilometers



Index maps of Massachusetts showing river basins (larger map) and total freshwater withdrawals by river basin (smaller map), 1990.

Table 1 - Area, population, and estimated withdrawals and hydroelectric instream use of water for river basins in Massachusetts, 1990

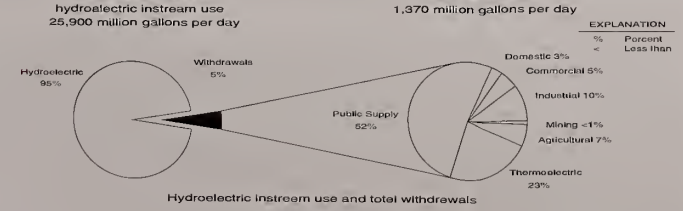
[Units are in million gallons per day (Mgal/d), except where noted; population numbers are rounded to the nearest hundred people, other numbers are rounded to the nearest 0.1 Mgal/d or to three significant figures; values may not add to totals because of independent rounding, mi², square miles]

Map code	[1]USGS River basin	Hydrologic catalog-ing unit	[2]Area (mi²)	Population (thousands)	Estimated withdrawals: Self-supplied: Public supply	Domes-tic	Commer-cial	Indus-trial	Mining	Agricul-ture	Thermo-electric	Total with-drawals	Hydro-electric instream use
1	Piscataqua-Salmon Falls	01060003	9	7.7	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.3	0.0
2	Merrimack	01070002	357	475.8	54.5	1.7	7.1	11.9	7	1	.0	76	.0
3	Nashua	01070004	443	229.2	67.5	3.6	4.3	15.1	7	.2	0	111	.0
4	Concord	01070005	401	364.4	30.1	2.6	6.7	5.0	1.0	1	.0	45.5	.0
5	Middle Connecticut	01080201	556	246.0	24.3	2.5	1.4	6.9	.0	.3	102	137	15,900
6	Millet	01080202	313	59.4	5.6	.9	.9	5.9	0	1	.0	13.4	.0
7	Deerfield	01080203	347	31.2	2.6	.7	.4	1.4	0	1	124	129	478
8	Chicopee	01080204	725	148.4	191	2.1	3.3	1.4	.0	.3	.0	196	1,930
9	Lower Connecticut	01080205	1,193	1,038	.0	.7	.5	.0	.0	80.2	81.4	6,340	
10	Westfield	01080206	516	87.5	47.3	1.8	2.6	3.9	0	.2	.0	55.8	.0
11	Farmington	01080207	182	3.8	.0	.3	.6	.0	0	.0	.0	.9	.0
12	Charles	01090001	1,120	2,495.5	91.1	3.6	28.1	20.6	5	7.2	.0	151	.0
13	Cape Cod	01090002	1,207	629.9	62.0	6.8	7.4	1.9	1.0	59.4	.5	139	.0
14	Blackstone	01090003	335	282.4	25.3	2.6	1.6	8.5	3	.2	.0	38.5	.0
15	Narragansett	01090004	661	541.7	67.8	3.5	6.0	3.3	6	33.3	0.2	115	.0
16	Quinebaug	01100001	249	90.3	6.1	2.0	1.2	12.7	.0	1	.0	22.1	.0
17	Shetucket	01100002	2	2.0	0	2	0	0	.0	.0	0	.2	0
18	Housatonic	01100005	500	91.3	14.4	7	9	24.2	.0	1	0	40.3	310
19	Hudson-Hoosic	02020003	127	41.2	5.4	4	3	5.8	.0	.0	0	11.9	0
20	Middle Hudson	02020005	37	8	0	1	1	0	.0	.0	.0	.2	.0
TOTAL			8,180	6,018.4	714	36.8	73.6	129	5.0	102	307	1,370	24,500

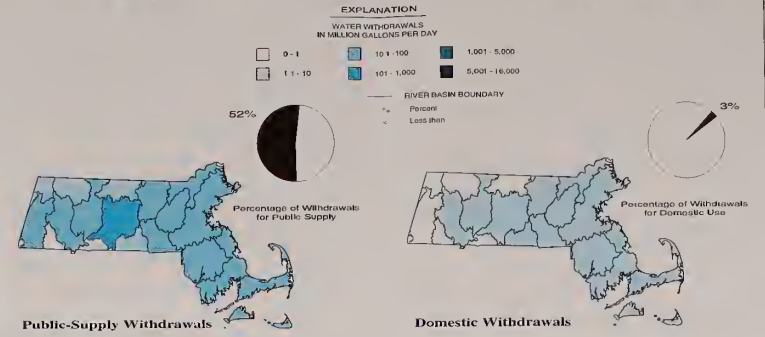
[1] Corresponding basin names used by Massachusetts State agencies are: Middle Connecticut (USGS), Connecticut (MA); Millet (USGS), Millers (MA); Lower Connecticut (USGS), Connecticut (MA); Charles (USGS), Blackstone, Parker, Ipswich, North Coastal, Boston Harbor, and Charles (MA); Cape Cod (USGS), South Coastal, Cape Cod, Islands, Buzzards Bay, and Massachusetts Coastal (MA); Narragansett (USGS), Taunton, Narragansett Bay Mt. Hope Bay Shore, and Tennessee (MA); Quinebaug (USGS), Quinebaug and French (MA); Shetucket (USGS), included in Quinebaug (MA); Middle Hudson (USGS), Hudson-Kinderhook and Hudson Basin/Tri (MA)

[2] Areas given for the Concord, Chicopee, and Charles Basins are from Seaber and others (1987), areas for other basins are calculated because river-basin boundaries extend beyond state boundaries.

A water withdrawal generally refers to water removed for use from streams, reservoirs, or the ground. However, water can also be used without being moved from the stream channel--this is called instream use. The major instream use in Massachusetts is hydroelectric-power generation. Hydroelectric instream use is discussed separately from withdrawals in this report for two reasons. First, unlike withdrawals, virtually no change in the quantity of the water takes place during instream use. Second, the volume of water used for hydroelectric-power generation is so large that it overshadows the combined withdrawals for all other uses. In Massachusetts, hydroelectric instream use is about 18 times the total withdrawals. Other important instream uses include navigation, wastewater assimilation, recreation, and aquatic habitat.



WITHDRAWALS BY WATER-USE CATEGORY AND RIVER BASIN



Public-Supply Withdrawals

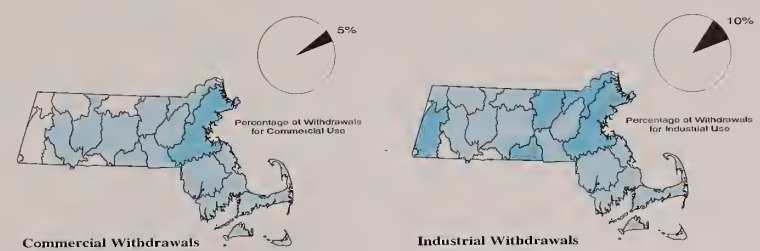
Public-supply withdrawals: Water withdrawn by public and private water suppliers who provide water to various users, such as domestic, commercial, and industrial users, and thermoelectric power plants. Public supply also includes public use, losses, and transfers to other public suppliers or basins.

* Public-supply withdrawals, 714 million gallons per day, accounted for 52 percent of total withdrawals.
* Public suppliers served approximately 5,504,600 people, about 91 percent of the State's population.
* The largest public water-supply system in the State is the Massachusetts Water Resource Authority, which serves 43 communities including much of metropolitan Boston from two large reservoirs--the Quabbin Reservoir in the Chicopee river basin (with withdrawals of 191 million gallons per day) and the Wachusett Reservoir in the Nashua river basin (with withdrawals of 87.5 million gallons per day). Public-supply withdrawals in the Charles river basin, which contains 41 percent of the State's population, were 91.9 million gallons per day and included water imported from the two reservoirs.

Domestic Withdrawals

Domestic withdrawals: Water withdrawn for normal household purposes in homes, apartments, or in any place where people are included in a census survey. Domestic withdrawals include water used for drinking, preparing food, bathing, washing clothes or dishes, flushing toilets, and watering lawns and gardens.

* Domestic self-supply withdrawals, 36.8 million gallons per day, accounted for 3 percent of total withdrawals.
* Approximately 511,800 people or about 9 percent of the State's population were self-supplied.
* The largest withdrawals for domestic self-supply were in the Cape Cod river basin (6.8 million gallons per day), and the Nashua and Charles river basins (each with 3.6 million gallons per day). These three basins contain 56 percent of the State's population.



Commercial Withdrawals

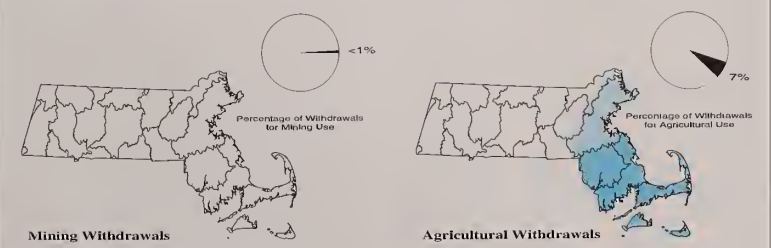
Commercial withdrawals: Water withdrawn for use in motels, hotels, restaurants, office buildings, and other commercial facilities, plus institutions, such as hospitals or schools. Water withdrawn for air conditioning and fish hatcheries also is included.

* Commercial self-supply withdrawals, 73.6 million gallons per day, accounted for 5 percent of total withdrawals.
* The largest withdrawals for commercial self-supply were in the Charles river basin (28.1 million gallons per day), because it contains the greater Boston area. Other basins with large commercial withdrawals were the Cape Cod river basin (7.4 million gallons per day) and the Merrimack river basin (7.1 million gallons per day)

Industrial Withdrawals

Industrial withdrawals: Water withdrawn for use in fabricating, processing, washing, and cooling industrial materials.

* Industrial self-supply withdrawals, 129 million gallons per day, accounted for 10 percent of total withdrawals.
* The largest withdrawals by industries were in the Housatonic river basin (24.2 million gallons per day), the Charles river basin (20.6 million gallons per day), and the Nashua river basin (15.1 million gallons per day)
* The largest industrial withdrawals in Massachusetts were for the paper manufacturing industry.



Mining Withdrawals

Mining withdrawals: Water withdrawn for use in extraction of minerals, which includes withdrawals associated with quarrying, dewatering, milling (crushing, screening, washing, flotation), and other preparations customarily done at the mine site or part of a mining activity.

* Mining withdrawals, 5.0 million gallons per day, accounted for less than 1 percent of total withdrawals. All mining operations in Massachusetts were assumed to be self-supplied.
* The largest withdrawals for mining were in the Cape Cod and Concord river basins (each with 1.0 million gallons per day)
* Sand and gravel operations were the major mining activities in Massachusetts.

Agricultural Withdrawals

Agricultural withdrawals: Water withdrawn for use in irrigation and livestock watering.

* Agricultural withdrawals, 102 million gallons per day, accounted for 7 percent of total withdrawals. All agricultural use in Massachusetts was assumed to be self-supplied.
* The largest withdrawals for agriculture were in the Cape Cod river basin (59.4 million gallons per day) and the Narragansett river basin (33.3 million gallons per day).
* Irrigation of cranberry bogs, which are grown on 70 percent of agricultural acreage in Massachusetts, accounted for 99 percent of total agricultural withdrawals.

Thermoelectric Withdrawals

Thermoelectric withdrawals: Water withdrawn for use in the process of generating thermoelectric power. The water is primarily used for cooling.

* Self-supply withdrawals for thermoelectric-power generation, 307 million gallons per day, accounted for 23 percent of total withdrawals.
* The largest withdrawals for thermoelectric power were in the Deerfield river basin (124 million gallons per day) and the Middle Connecticut river basin (102 million gallons per day).
* Other fossil-fuel and nuclear powerplants in Massachusetts used saline water, so their use of water is not included in this report.

Hydroelectric Instream Use

Hydroelectric instream use: Water used in the generation of electricity at plants where the turbine generators are driven by moving water.

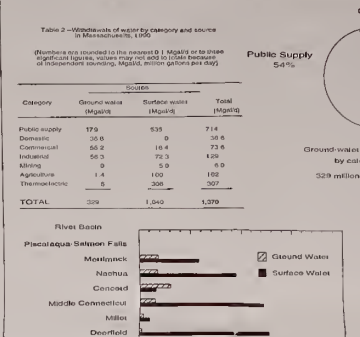
* Hydroelectric instream use, 24,500 million gallons per day, was about 18 times the total volume of water withdrawn for all other uses.
* The Middle and Lower Connecticut river basins contain 15 of 23 hydroelectric powerplants. In the State and account for 91 percent of total hydroelectric instream use.

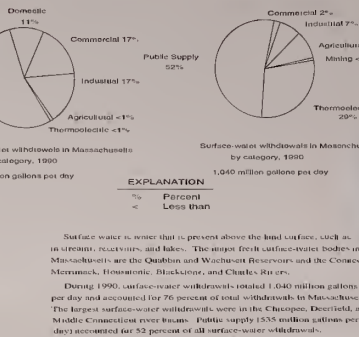
SURFACE-WATER AND GROUND-WATER WITHDRAWALS

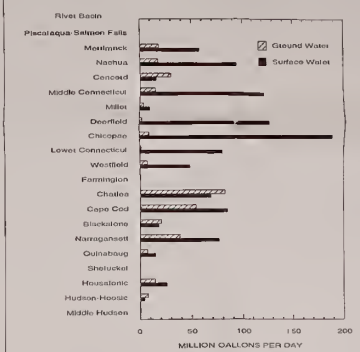
Table 2--Withdrawals of water by category and source in Massachusetts, 1990

[Numbers are rounded to the nearest 0.1 Mgal/d or to three significant figures, values may not add to totals because of independent rounding; Mgal/d, million gallons per day]

Category	Source: Ground water (Mgal/d)	Surface water (Mgal/d)	Total (Mgal/d)
Public supply	179	535	714
Domestic	36.8	0	36.8
Commercial	58.2	16.4	73.6
Industrial	58.3	72.3	129
Mining	5.0	5.9	5.9
Agriculture	1.4	100	102
Thermoelectric	5	306	307
TOTAL	329	1,040	1,370







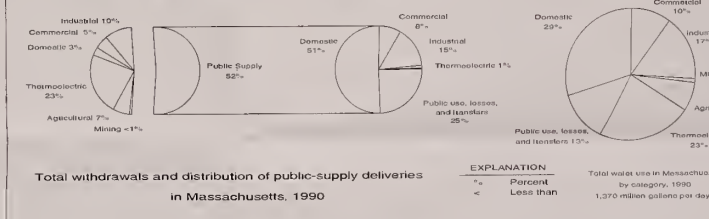
Surface water is water that is present above the land surface, such as in streams, reservoirs, and lakes. The major fresh surface-water bodies in Massachusetts are the Quabbin and Wachusett Reservoirs and the Connecticut, Merrimack, Housatonic, Blackstone, and Charles Rivers.

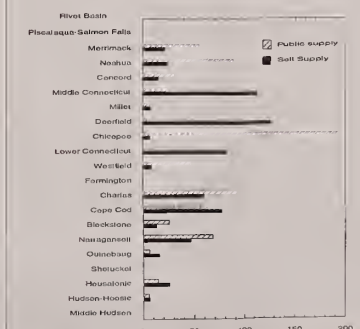
During 1990, surface-water withdrawals totaled 1,040 million gallons per day and accounted for 76 percent of total withdrawals in Massachusetts. The largest surface-water withdrawals were in the Chicopee, Deerfield, and Middle Connecticut river basins. Public supply (535 million gallons per day) accounted for 52 percent of all surface-water withdrawals. Thermoelectric-power generation (306 million gallons per day) accounted for 29 percent of all surface-water withdrawals.

Ground water is the subsurface water that is present beneath the water table in soils and geologic formations that are fully saturated. When geologic formations yield significant quantities of water, they can be referred to as aquifers. Massachusetts has four main types of aquifers--those in glacial deposits (such as stratified drift or till), in crystalline bedrock (such as schist or gneiss), in sedimentary bedrock, and in carbonate bedrock (such as marble).

During 1990, ground-water withdrawals totaled 329 million gallons per day and accounted for 24 percent of total withdrawals in Massachusetts. The largest ground-water withdrawals were in the Charles river basin despite the fact that the Massachusetts Water Resource Authority serves metropolitan Boston in the basin. This is primarily because suburban Boston has only ground-water sources. The Cape Cod river basin had the second largest ground-water withdrawals. Public supply (179 million gallons per day) accounted for 54 percent of all ground-water withdrawals. Industrial use (56.3 million gallons per day) accounted for 17 percent, commercial withdrawals (55.2 million gallons per day) for 17 percent, and domestic withdrawals (36.8 million gallons per day) accounted for 11 percent of all ground-water withdrawals.

SELF-SUPPLY WITHDRAWALS AND PUBLIC-SUPPLY DELIVERIES





Public-supply water is water withdrawn by public and private water suppliers who provide water to various users, such as domestic, commercial, industrial users, and thermoelectric powerplants. It also includes public use (water used for fire fighting, hydrant flushing, sanitation, and park), losses, that result from leaks in the distribution system, transfers to or from other river basins, and meter errors that may over-register or under-register the actual volume of water flowing through the meter. In the table below, large positive values in the column headed "Public use, losses, and transfers" reflect large exports of public-supply water to other river basins, whereas large negative values reflect large imports.

During 1990, withdrawals for public supply totaled 714 million gallons per day, which accounted for 52 percent of the water withdrawn in Massachusetts. Public use, losses, and transfers were included in this amount and accounted for 25 percent of public-supply withdrawals. The largest public-supply deliveries were in the Charles river basin, where the Boston metropolitan area is located. Although the table below shows that the largest public-supply deliveries, 191 million gallons per day, are in the Chicopee river basin, almost 177 million gallons per day, or 93 percent of that water, is exported from the basin by the Massachusetts Water Resource Authority for use in other basins. The largest category of public-supply water, 365 million gallons per day, was domestic, which accounted for 51 percent of public-supply water. Industrial use (108 million gallons per day, 15 percent) and commercial use (58.1 million gallons per day, 8 percent) were the second and third largest uses of public-supply water. Less than 1 percent of public-supply water was for thermoelectric use, other categories were assumed to have no public-supply deliveries.

Self-supply water is water that is withdrawn from a surface-water or ground-water source by a user rather than being obtained from a public supplier. During 1990, self-supply withdrawals were 655 million gallons per day, 48 percent of water withdrawn in Massachusetts. The largest self-supply withdrawals were in the Deerfield and Middle Connecticut river basins. In 1990, the largest use of self-supply water, 307 million gallons per day, was for cooling in thermoelectric powerplants and accounted for 47 percent of self-supply water. The second largest use of self-supply water was for industrial use, 129 million gallons per day, or about 20 percent of self-supply. Agricultural use of 102 million gallons per day, entirely self-supplied, accounted for 16 percent of self-supply water.

Total water use is the quantity of water use for a specific category and is the combination of self-supply withdrawals and public-supply deliveries. The domestic-use category, which only accounts for 3 percent of total withdrawals, is the largest total water-use category (29 percent) in Massachusetts.

Table 3.--Use of water by category and supply type in Massachusetts, 1990

[Numbers exclude hydroelectric instream use, values are rounded to nearest 0.1 Mgal/d or to three significant figures; values may not add to totals because of independent rounding; Mgal/d, million gallons per day]

Category	Supply type: Public supply (Mgal/d)	Self supply (Mgal/d)	Total (Mgal/d)
Domestic	365	36.8	402
Commercial	58.1	73.6	132
Industrial	108	129	237
Mining	0	5.9	5.9
Agriculture	0	102	102
Thermoelectric	4.8	307	311
Public use, losses, and transfers	179	0	179
TOTAL	714	655	1,370

Table 4.--Population with public and self-supply water, and public-supply deliveries of water in Massachusetts, 1990

[Units are in million gallons per day (Mgal/d), except where noted, population numbers are rounded to the nearest hundred people, other numbers are rounded to the nearest 0.1 Mgal/d or to three significant figures, values may not add to totals because of independent rounding]

River Basin	Population with public supply (thousands)	Population with self-supply (thousands)	Public-supply deliveries: Public use, losses, and transfers	Domestic	Commercial	Industrial	Thermo-electric	Total
Pisca/aqua-Salmon Falls	7.3	0.4	0.5	0.6	0.0	0.0	0.0	0.0
Merrimack	452.9	23.0	14.6	24.6	4.8	10.3	0	54.5
Nashua	179.6	50.4	65.7	12.6	3.3	6.9	0	67.5
Concord	207.9	36.4	-2.1	21.0	4.9	6.3	0	30.1
Middle Connecticut	211.6	34.4	3.6	17.5	2.1	1.7	0	24.3
Millet	47.5	11.9	2.5	2.3	.3	.5	0	5.6
Deerfield	20.9	19.7	-1.9	1.6	.7	1.6	0	3.6
Chicopee	110.7	29.7	177	8.1	2.8	3.3	0	191
Lower Connecticut	163.5	9.7	-1.8	0	0	0	1.8	0
Westfield	62.1	25.4	10.7	21.4	5.0	0	0	47.3
Farmington	2.4	3.8	.7	.4	.2	0	0	.9
Charles	2,445.7	49.8	-129	158	14.9	46.2	1.9	94.1
Cape Cod	345.7	30.7	27.4	36.4	7.3	6.6	.4	52.0
Blackstone	345.7	30.7	7.4	9.6	1.3	8.0	0	23.3
Narragansett	492.9	48.8	18.0	32.0	9.7	6.6	1.3	57.6
Quinebaug	92.3	26.0	4	3.5	.7	2.3	0	6.1
Shetucket	0	2.0	0	0	0	0	0	0
Housatonic	91.2	19.5	2.1	8.5	1.4	2.4	0	14.4
Hudson-Hoosic	35.4	5.8	1.5	3.0	.7	.2	0	5.4
Middle Hudson	0	0	0	0	0	0	0	0
TOTAL	5,504.6	341.8	179	365	51.1	106	4.6	714

ESTIMATED WITHDRAWALS AND USE OF FRESHWATER IN MASSACHUSETTS, 1990

By
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1996

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